PROVISIONAL

DELIVERY GUIDE

Topic P3: Electricity

September 2015

GCSE (9–1) Gateway Physics A

Oxford Cambridge and RSA

We will inform centres about any changes to the specification. We will also publish changes on our website. The latest version of our specification will always be the one on our website (www.ocr.org.uk) and this may differ from printed versions.

Oxford Cambridge and RSA Examinations is a Company Limited by Guarantee. Registered in England. Registered company number 3484466.

Registered office: 1 Hills Road
Cambridge
CB1 2EU

OCR is an exempt charity.

CONTENTS

PROVISIONAL

This resource is an exemplar of the types of materials that will be provided to assist in the teaching of the new qualifications being developed for first teaching in 2016. It can be used to teach existing qualifications but may be updated in the future to reflect changes in the new qualifications. Please check the OCR website for updates and additional resources being released. We would welcome your feedback so please get in touch.

Introduction

Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- Content: A clear outline of the content covered by the delivery guide;
- Thinking Conceptually: Expert guidance on the key concepts involved, common difficulties students may have, approaches to teaching that can help students understand these concepts and how this topic links conceptually to other areas of the subject;
- Thinking Contextually: A range of suggested teaching activities using a variety of themes so that different activities can be selected which best suit particular classes, learning styles or teaching approaches.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resourcesfeedback@ocr.org.uk.

KEY

Click to view associated resources within this document.

Click here to see the clip

Click to view external resources.

Curriculum Content P3.1 Static and charge

Mathematical learning outcomes

PM3.1i: recall and apply: charge flow (C)= current (A) x time (s)

Assessable content statements

a) *describe that charge is a property of all matter, that there are positive and negative charges, but the effects of the charges are not normally seen as bodies containing equal amounts of positive and negative charge so their effects cancel each other out*

b) *describe the production of static electricity, and sparking, by rubbing surfaces, and evidence that charged objects exert forces of attraction or repulsion on one another when not in contact*

c) *explain how transfer of electrons between objects can explain the phenomena of static electricity*

d) *explain the concept of an electric field and how it helps to explain the phenomena of static electricity*

e) *recall that current is a rate of flow of charge (electrons) and the conditions needed for charge to flow*

f) *recall and use the relationship between quantity of charge, current and time*

Thinking Conceptually P3.1 Static and charge

Approaches to teaching the content

Learners should understand that charge is a property of all matter, yet the effects of which are not normally seen as the charges balance.

When some insulating materials are rubbed, they can become electrically charged due to the transfer of electrons. The material that gains the electrons become negatively charged and the material that loses the electrons becomes positively charged.

A charged material/object can exert a force on a non-charged object, as well as two charged materials exerting a force on each other. The principal of the force is similar to that of magnets; materials carrying the same charge will repel each other, and materials carrying opposite charges will attract.

Common misconceptions or difficulties students may have

Many learners find it difficult to separate static and conventional electricity, so it is important to reiterate the differences.

The following paper is a great resource to help design activities and develop the learner's own understanding. It is designed for younger learners however, but can be used with those who have little Key Stage 3 knowledge of static electricity.

http://web.missouri.edu/~hanuscind/4280/WhyStaticClings.pdf

Thinking Contextually P3.1 Static and charge

Approaches to teaching the content

A good way to introduce static electricity is to ask if learners have noticed a crackling sound or if their hair sticks up when they take off their school jumper. Learners can be asked if they can explain why. These initial answers can be used to highlight misconceptions, and then revisited throughout the lesson and demonstrate progress.

Lightning is a good example of static charge that then moves. A starter of 'who will be struck by lightning', with different characters could be used. Pictorial form would be a very visual way to present this idea.

Person 1 – holding a kite in a thunderstorm

Person 2 – sitting in a car in a thunderstorm

Person 3 – standing out in an open field during a thunderstorm

Activities P3.1 Static and charge

Activities	Resources
Activity 1 **Experiments with a Van de Graff generator** The Nuffield Foundation http://www.nuffieldfoundation.org/practical-physics/experiments-van-de-graaff-generator http://www.nuffieldfoundation.org/practical-physics/van-de-graaff-generator-safety This demonstration is a fun way to show the effects of electrostatic charge. The web page includes instructions of how to carry out the demonstration, with dated, yet informative illustrations of how the charges differ once the generator is turned on. Please see Nuffield Foundation safety instructions and consult lab technicians, as individual generators may differ.	Click here Click here
Activity 2 **Electrostatics** The Nuffield Foundation http://www.nuffieldfoundation.org/practical-physics/electrostatics A range of insulating materials can be used to demonstrate this phenomenon. Using a duster to rub a plastic rod can be used to pick up small pieces of torn paper. This activity can be turned into a competition amongst the class, or as a basis of experimental work investigating which factors affect how many pieces of paper can be picked up. A charged rod held next to a stream of water from a tap will move the water. To extend the ideas found on the web page, learners could answer why this method doesn't work on metal rods.	Click here
Activity 3 **Create your own lightning** Planet Science http://www.planet-science.com/categories/under-11s/our-world/2011/05/what-is-lightning.aspx A fun and simple experiment by Planet Science to demonstrate static charge.	Click here

Curriculum Content P3.2 Simple Circuits

Mathematical learning outcomes

PM 3.2i: recall and apply: potential difference (V)= current (A) x resistance (Ω)

PM3.2ii: recall and apply: energy transferred (J) = charge (C) x potential difference (V)

PM3.2iii: recall and apply: power (W) = potential difference (V) x current (A) = (current (A))2 x resistance (Ω)

PM 3.2iv: recall and apply: energy transferred (J, kWh) = power (W, kW) x time (s, h) = charge (C) x potential difference (V)

Assessable content statements

a) *describe the differences between series and parallel circuits*

b) *represent d.c. circuits with the conventions of positive and negative terminals, and the symbols that represent common circuit elements*

c) *recall that current (I) depends on both resistance (R) and potential difference (V) and the units in which these are measured*

d) *recall and apply the relationship between I, R and V, and that for some resistors the value of R remains constant but that in others it can change as the current changes*

e) *explain the design and use of circuits to explore such effects*

f) *use graphs to explore whether circuit elements are linear or non-linear*

g) *use graphs and relate the curves produced to the function and properties of circuit elements*

h) *explain, why, if two resistors are in series the net resistance is increased, whereas with two in parallel the net resistance is decreased (qualitative explanation only)*

i) *calculate the currents, potential differences and resistances in d.c. series and parallel circuits*

j) *explain the design and use of such circuits for measurement and testing purposes*

k) *explain how the power transfer in any circuit device is related to the potential difference across it and the current, and to the energy changes over a given time*

l) *apply the equations relating potential difference, current, quantity of charge, resistance, power, energy, and time, and solve problems for circuits which include resistors in series, using the concept of equivalent resistance*

Thinking Conceptually P3.2 Simple Circuits

Approaches to teaching the content

Electric current

It would be a good idea to revisit Key Stage 3 content in order to highlight misconceptions or gaps in knowledge and understanding.

Areas to revisit include:

- Definitions of key terms such as current, p.d, charge, static electricity, parallel circuit, series circuit, resistance (maybe some higher ability learners have covered this), conductor and insulator.
- Conditions needed for current to flow.
- The names and symbols of common components such as diodes, LDRs, thermistors, filament bulbs, ammeter, voltmeter and resistor.
- Ability to draw series and parallel circuits, using component symbols as above.

How to measure current and p.d. in a series and parallel circuit.

Potential Difference and Resistance

Thus far the term voltage has been used in order to establish confidence in Key Stage 3 knowledge. In order to move on to understand the various behaviours of components within a circuit, the term p.d. (potential difference) should be used. More able learners may feel comfortable using the term p.d. from the outset of the GCSE course. The p.d. is defined as the difference in energy transferred between any two points in a circuit, per coulomb of charge that passes between those points.

When a current flows through a piece of wire, for example, the free moving electrons collide with the ions on the metal. This collision causes resistance. In order to understand this, learners will need to have knowledge of metallic structures from Chemistry GCSE.

Learners should understand the equation that is based on Ohm's Law, which states that p.d. is directly proportional to current:

potential difference (V)= current (A) x resistance (Ω)

The relationship between the current and the p.d. is a constant, as long as the temperature stays the same. This relationship can be illustrated through undertaking practical work based on Ohmic components such as wires.

The following website from Spark Fun is a great resource to understanding the basic terms of resistance and resistors

https://learn.sparkfun.com/tutorials/resistors

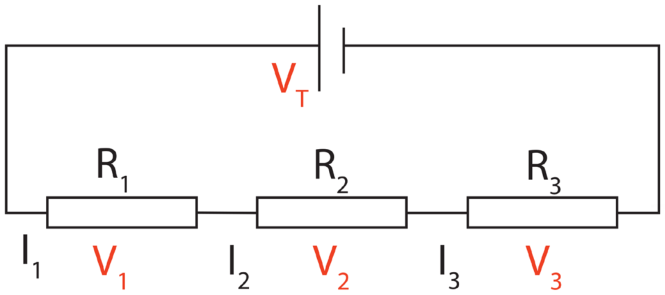
Linear & Non-Linear circuit elements

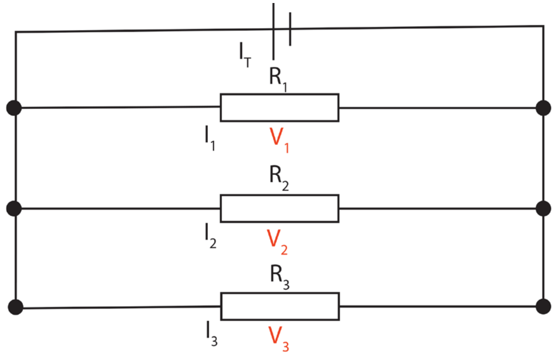
Resistors are examples of circuit components that are linear and therefore referred to an ohmic. A component that is non-linear does not have a linear relationship between current and p.d. i.e. as p.d. doubles, the current does not.

Examples of components to use are:

- Resistors
- Semiconductor diodes
- Thermistors
- LDRs
- Filament lamps
- Wires

Resistors in Series and Parallel





In the series circuit above:

$I_1 = I_2 = I_3$

The current is the same anywhere in the circuit.

Total voltage = $V_1 + V_2 + V_3$

The p.d. is different in different parts of the circuit, yet adds up to the total p.d. input.

These concepts are not new (taught at Key Stage 3 and revisited at the start of the topic).

Total resistance = $R_1 + R_2 + R_3$

In the parallel circuit above:

Total current = $I_1 + I_2 + I_3$

$V_1 = V_2 = V_3$

1/ total resistance = $\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Thinking Conceptually P3.2 Simple Circuits

Energy Transfers in a Circuit

Ideas surrounding energy transfers can be explored when introducing this part of the topic. This topic requires learners to move on from Key Stage 3 where they have looked at types of energy transfer, to now calculating the amount of energy transferred using the following equation:

energy transferred (J) = charge (C) x potential difference (V)

So 1 volt = 1 joule of energy per coulomb of charge

Learners can also use:

energy transferred (J) = current (A) x time (s) x potential difference (V)

Electrical Power

The word 'power' may hold very different meanings for different learners, so it is important to address these and link them to the scientific meaning as much as possible.

Here we start to link different formulae together and see the connection between energy, power, p.d. and current.

So while:

energy transferred (J) = current (A) x time (s) x potential difference (V)

and

power (W) = potential difference (V) x current (A)

These can be combined to say that:

energy transferred (J) = power (W) x time (s)

For resistors we can combine

power (W) = potential difference (V) x current (A)

potential difference (V) = current (A) x resistance (Ω)

to give: power (W) = (current (A))^2 x resistance (Ω)

Thinking Conceptually P3.2 Simple Circuits

Common misconceptions or difficulties learners may have

Electric current

The very nature of current, charge and electricity means we are unable to see it, we can only experience the effects of it. Learners therefore find electricity difficult to conceptualize. Models or analogies are good techniques to use to help learners visualize and understand elements of this topic.

The following links from the Nuffield Foundation called Models of Electric Circuits details a range of possible misconceptions, and includes models that teachers can use to help learners reconceptualise their ideas.

http://www.nuffieldfoundation.org/practical-physics/models-electric-circuits

http://www.nuffieldfoundation.org/practical-physics/water-circuit-modelling-current-and-potential-difference

Linear & Non-Linear circuit elements

Learners can become confused when we start to discuss circuit components that do not obey Ohm's law. For many materials the resistance is constant independent of current and p.d. These materials are ohmic. Materials which are non-ohmic can be more challenging to understand. Practical work and graphical representation should help learners understand that resistance can change.

Explaining the shape of the I-V curve for a filament bulb can be challenging. An increase in p.d. causes the temperature of the filament to rise and as a result ions begin to vibrate more. This leads to a higher frequency of collisions between electrons and ions, thus the resistance increases.

When discussing how temperature affects resistance learners may be confused when a bulb and a thermistor are compared. In a thermistor, resistance decreases as its temperature increases. The relationship between resistance and temperature is not the same for all circuit components.

Resistors in Series and Parallel

The differences in current and p.d. in a series and parallel circuit can be difficult to understand. In a series circuit, the current and resistance can be explained using the same idea: there is one route for the current to flow so the current going into the circuit from the cell is the same as the current returning to the cell. Therefore the current flowing through each resistor must be the same, and so the calculation $R = V/I$ can be used quite easily. Learners find it a challenge to apply the rules they know for the behaviour of current and p.d. in parallel circuits to use to calculate resistance of components within these.

Energy Transfers in a Circuit & Electrical Power

This area of the topic introduces more units of measurement which are easy to confuse. An example would be the use of both J and kWh as units of energy, many learners posit kWh as a unit of power.

Thinking Contextually P3.2 Simple Circuits

Approaches to teaching the content

Electric current

Electricity is all around us. Asking learners in the lesson to spend a typical day without electricity makes them aware of how much we rely on electricity, and the possible implications of that. You may wish to have a small discussion about the fuels needed to supply this much electrical energy, and the consequences of that need.

Resistance and p.d.

Fuses are examples of how resistance is used for safety. Learners can be given a fuse and asked to look at how thin the piece of wire is. The idea of a fuse saving lives can be used as the big idea of the lesson. Investigations which demonstrate how wire thickness affects resistance will help learners to understand why fuses are designed as they are, and how they break circuits.

Energy transfers in a circuit and electrical power

When starting to apply the mathematical element of this topic it is important to relate the information to what learners know about electrical appliances. Ask them to find out the power of some electrical appliances they have at home. What does the word 'power' mean in these instances?

In the context of the home, the same equations are used as above, but with different units. This can be confusing for learners.

The following equation is used to calculate a cost of energy, note the different units.

Energy transferred (kWh) = power (kW) x time (h)

The amount of energy transferred can then be multiplied by a unit of cost, eg 7p per kWh and the total cost calculated.

This calculation can be applied to the cost of electricity in the home, oil prices and charges set by energy companies can be used to discuss the future of our energy supplies.

Activities P3.2 Simple Circuits

Activities	Resources
Activity 1 Revision activity My Physics http://www.myphysics.org.uk/ks4p5sskeywords.htm A general revision tool in a card sort activity can be found on the My Physics website. This is an interactive task for learners to check their knowledge of terms and definitions, comprising of 20 questions.	Click here
Activity 2 Answering longer answer questions My Physics http://www.myphysics.org.uk/docs/ks4lorqusp5.pdf This website provides learners and teachers with guidance on how to write long written answers, or those questions with a QWC mark awarded (quality of written communication).	Click here
Activity 3 **Electric current** Supporting Physics Teaching http://supportingphysicsteaching.net/EeHome.html The institute of Physics have provided a vast amount of resources and information on their website. As well as activities and diagrams, each link includes tips on how you can teach the topic to improve learner understanding, as well what difficulties learners may come across.	Click here

Activities P3.2 Simple Circuits

Activities	Resources
Activity 4 **Measuring current and p.d. in different circuits** The Nuffield Foundation http://www.nuffieldfoundation.org/practical-physics/investigating-current-around-circuit The webpage details a range of practical activities in order to investigate resistance, including how fuses work.	Click here
Activity 5 **Investigating factors that affect resistance** http://www.ocr.org.uk/Images/251785-investigating-factors-that-affect-resistance-activity-lesson-element.doc http://www.ocr.org.uk/Images/251784-investigating-factors-that-affect-resistance-teacher-instructions-lesson-element.pdf A practical is an excellent way to illustrate the relationship between I, R and V. Practicals help learners to master the skills necessary for all GCSE Science subjects. As well as engaging learners in the lesson itself, practical elements help learners to understand concepts via exploration. Investigative skills can certainly be developed here, and asking learners to make sense of findings or explaining their findings by use of a rule or relationship between factors is one method of achieving this. Investigations into the effect of wire length, wire diameter, wire material (copper vs nichrome) and different components can be included to investigate the relationship between current, resistance and voltage.	Click here Click here
Activity 6 **Testing understanding of circuits** TES Teaching Resources https://www.tes.co.uk/teaching-resource/Series-and-Parallel-Circuits-Voltage-and-Current-6429018 The worksheet from TES can be used to test learners' understanding of the differences in current and p.d in a series and parallel circuit.	Click here

Activities P3.2 Simple Circuits

Activities	Resources
Activity 7 **Resistance Effects** The Nuffield Foundation http://www.nuffieldfoundation.org/practical-physics/resistance-effects The webpage details a range of practical activities in order to investigate resistance, including how fuses work.	Click here
Activity 8 **Creating Curious Circuits** The Institute of Engineering and Technology http://faraday.theiet.org/resources/overview/curious-circuits.cfm The following link from The Institute of Engineering and Technology requires a free registration, and directs you to an extension activity, with an overview and three worksheets for learners to follow. The activity involves making conductive dough to explore different types of circuits. Learners build creative circuit models and then measure p.d. and current to calculate resistance.	Click here
Activity 9 **Temperature Change and Resistance** The Nuffield Foundation http://www.nuffieldfoundation.org/practical-physics/temperature-change-and-resistance The following link directs learners how to investigate the changing resistance of a wire as it heats up. As well as learner instructions, there are also teaching notes and health and safety procedures. This practical is an excellent way to graph results and the same procedure can be used to test the linearity of different circuit elements, such as filament lamps, semi-conductor diodes, thermistors and LDRs.	Click here

Activities P3.2 Simple Circuits

Activities	Resources
Activity 10 **Resistors in circuits** Physics Net http://physicsnet.co.uk/a-level-physics-as-a2/current-electricity/circuits/ This is a great resource where all the various factors in a circuit have been collated together, and can be compared easily. This is a resource for teachers as opposed to learners.	Click here
Activity 11 **Resistors in series and parallel** TES Teaching Resources https://www.tes.co.uk/teaching-resource/resistors-in-series-and-parallel-3001091 The worksheet from TES is great for learners to work through in their own time. It comes with an example then questions that follow.	Click here
Activity 12 **Energy Transfers in a Circuit and Electrical Power** TES Teaching Resources https://www.tes.co.uk/teaching-resource/Calculating-Energy-Costs-6366624 The YouTube video is a worked example of applying the electricity equations in the context of household appliances.	Click here
Activity 13 **Calculation revision** https://www.youtube.com/watch?v=v7ndmZfRPjU The YouTube video is more of a revision aid, but highlights some important factors learners need to remember when using the calculations.	Click here to see the clip

Teacher Resource 1 Circuit modelling activity - The waterfall analogy

Learning outcomes

To use models to analyse the behaviour of p.d.

Description of activity

This very short activity of modelling is a great way to get the learners engaging in higher order thinking. Being able to identify the different components each part of the model represents, evaluating it (is it a good or bad model?), and offering modifications are all higher-level tasks. Not only can learners evaluate the teacher's model, they can design their own and evaluate each other's in a peer review task.

Introduction to the task, for the teacher

With this waterfall analogy, different heights of waterfall can be compared, with the use of a video or photos to illustrate the differences.

Charge = water. The flow of current around a circuit can be compared to the water flowing in a waterfall. The movement of charged particles (electrons) is modelled by the movement of water.

Current = rate of water flow, how much water is flowing over the edge every second.

p.d = height of the waterfall. This is where different heights of waterfall can be introduced, and compared to the p.d of different cells ie the higher the waterfall is the more stored energy the water has.

Instructions

1. With the use of a headed table, learners can watch a video or look at some photos of waterfalls and identify what part of the waterfall represents parts of electrical circuits.
2. Learners evaluate these models. Are they good or bad, and why?
3. Learners can design their own model, in groups perhaps, and then peer assess each other's models using the same table as used previously.

Suggestions for extension activities

To extend this task, learners can offer modifications to peer models and explain why modifications need to be made. *'I would choose X to represent charge because…'*

ocr.org.uk/gcsereform
OCR customer contact centre

General qualifications
Telephone 01223 553998
Facsimile 01223 552627
Email general.qualifications@ocr.org.uk